Claims

What is claimed is:

1. A photovoltaic cell for converting radiant energy into electrical current and voltage, the electrical current created by charge carrier movement, the photovoltaic cell comprising:

a compliant substrate comprising:

a base layer of silicon having a layer of perovskite oxide positioned thereon and a layer of silicon oxide interposed there-between, the silicon oxide layer providing interfacial stress relief to the overlying perovskite oxide layer, allowing the compliant substrate to accommodate growth of semiconductor materials having a lattice constant from about 5.4Å to about 5.9Å;

a first subcell monolithically stacked on the compliant substrate, the first subcell having a junction of at least one p-type layer of semiconductor material in face-to-face contact with at least one n-type layer of semiconductor material, the first subcell having a lattice constant accommodated by the compliant substrate, and wherein the first subcell has a predetermined first band-gap energy; and

terminals attached to the photovoltaic cell to conduct current from and into the photovoltaic cell.

2. The photovoltaic cell of claim 1 further comprising:

a first passivation/confinement cladding layer interposed between the compliant substrate and the first subcell and a second passivation/confinement cladding layer positioned on the first subcell, the first and second passivation/confinement cladding layers comprising materials to minimize the interfacial recombination of carriers within the first subcell, and thereby facilitating the first subcell's current and voltage.

3. The photovoltaic cell of claim 1 wherein the perovskite oxide is strontium titanate ($SrTiO_3$).

4. The photovoltaic cell of claim 1 wherein the perovskite oxide is barium titanate ($BaTiO_3$).

5. The photovoltaic cell of claim 3 wherein the photovoltaic cell is a solar photovoltaic cell.

6. The photovoltaic cell of claim 3 wherein the photovoltaic cell is a thermophotovoltaic cell.

7. The photovoltaic cell of claim 5 wherein the first subcell is fabricated from a semiconductor material selected from a group consisting essentially of GaAs, InP, $GaAs_xP_{1-x}$, $Ga_xIn_{1-x}P$, $Ga_xIn_{1-x}As$, $GaAs_xSb_{1-x}$, $Al_xIn_{1-x}As$, $Al_xGa_{1-x}As$, $Al_xGa_yIn_{1-x-y}P$, $Ga_xIn_{1-x}As_yP_{1-y}$, $Al_xGa_{1-x}As_ySb_{1-y}$, $Al_xGa_yIn_{1-x-y}As$, and Ge_xSi_{1-x}, wherein x and y are values from 0 to 1 and the sum of x and y in any one semiconductor material is from 0 and 1.

8. The photovoltaic cell of claim 5 wherein the first subcell is fabricated from a semiconductor material selected from a group consisting of GaAs and InP.

9. The photovoltaic cell of claim 6 wherein the first subcell is fabricated from a semiconductor material selected from a group consisting of Ge, Ge_xSi_{1-x}, $Ga_xIn_{1-x}As$, $InAs_xP_{1-x}$, $GaAs_xSb_{1-x}$, $Ga_xIn_{1-x}As_yP_{1-y}$, and $Ga_xIn_{1-x}As_ySb_{1-y}$, wherein x and y are values from 0 to 1 and the sum of x and y in any one semiconductor material is from 0 to 1.

10. The photovoltaic cell of claim 6 wherein the first subcell is fabricated from a semiconductor material selected from a group consisting of Ge.

11. The photovoltaic cell of claim 2 further comprising:

a second subcell monolithically stacked on the first subcell, the second subcell having a junction of at least one p-type layer of semiconductor material in face-to-face contact with at least one n-type layer of semiconductor material, wherein the second subcell has a lattice constant matched to the lattice constant of the first subcell and wherein the second subcell has a predetermined second band gap energy, the second band gap energy being greater than the first band gap energy; and

a first interconnection layer interposed between the second passivation/confinement cladding layer and the second subcell, the interconnection layer comprising materials that facilitate current flow between the first subcell and the second subcell.

12. The photovoltaic cell of claim 11 further comprising:

a third passivation/confinement cladding layer interposed between the first interconnection layer and the second subcell, and a fourth passivation/confinement cladding layer positioned on the second subcell, wherein the third and fourth passivation/confinement cladding layers comprise materials for minimizing the

interfacial recombination of carriers within the second subcell and thereby facilitating the second subcell's current and voltage.

13. The photovoltaic cell of claim 11 wherein the perovskite oxide is strontium titanate ($SrTiO_3$).

14. The photovoltaic cell of claim 11 wherein the perovskite oxide is barium titanate ($BaTiO_3$).

15. The photovoltaic cell of claim 11 wherein the photovoltaic cell is a solar photovoltaic cell.

16. The photovoltaic cell of claim 12 wherein the photovoltaic cell is a thermophotovoltaic cell.

17. The photovoltaic cell of claim 15 wherein the first subcell is fabricated from GaAs and the second subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x is from 0 to 1.

18. The photovoltaic cell of claim 15 wherein the first subcell is fabricated from $Ga_xIn_{1-x}As$ and the second subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x is from 0 to 1.

19. The photovoltaic cell of claim 15 wherein the first subcell is fabricated from $Ga_xIn_{1-x}As$ and the second subcell is fabricated from InP, wherein x is from 0 to 1.

20. The photovoltaic cell of claim 15 wherein the first subcell is fabricated from $Ga_xIn_{1-x}As$ and the second subcell is fabricated from $Ga_xIn_{1-x}As_yP_{1-y}$, wherein x and y are from 0 to 1 and the sum of x and y is from 0 and 1.

21. The photovoltaic cell of claim 16 wherein the first subcell is fabricated from $Ga_yIn_{1-y}As$ and the second subcell is fabricated from $Ga_xIn_{1-x}As$, wherein x and y are from 0 to 1.

22. The photovoltaic cell of claim 16 wherein the first subcell is fabricated from $Ga_uIn_{1-u}As_vP_{1-v}$ and the second subcell is fabricated from $Ga_xIn_{1-x}As_yP_{1-y}$, wherein x, y, u and v are from 0 to 1 and the sum of any combination of x, y, u and v is from 0 to 1.

23. The photovoltaic cell of claim 2 further comprising:

a second subcell monolithically stacked on the first subcell, the second subcell having a junction of at least one p-type layer of semiconductor material in face-to-face contact with at least one n-type layer of semiconductor material, wherein the second subcell has a lattice constant matched to the lattice constant of the first subcell and

wherein the second subcell has a predetermined second band gap energy, the second band gap energy greater than the first band gap energy; and

a first isolation layer interposed between the second passivation/confinement cladding layer and the second subcell, the isolation layer comprising materials that prevents current flow between the first subcell and the second subcell.

24. The photovoltaic cell of claim 23 wherein the photovoltaic cell is a solar photovoltaic cell.

25. The photovoltaic cell of claim 23 wherein the photovoltaic cell is a thermophotovoltaic cell.

26. The photovoltaic cell of claim 24 wherein the first subcell is fabricated from GaAs and the second subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x is from 0 to 1.

27. The photovoltaic cell of claim 24 wherein the first subcell is fabricated from $Ga_xIn_{1-x}As$ and the second subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x is from 0 to 1.

28. The photovoltaic cell of claim 24 wherein the first subcell is fabricated from $Ga_xIn_{1-x}As$ and the second subcell is fabricated from InP, wherein x is from 0 to 1.

29. The photovoltaic cell of claim 24 wherein the first subcell is fabricated from $Ga_xIn_{1-x}As$ and the second subcell is fabricated from $Ga_xIn_{1-x}As_yP_{1-y}$, wherein x and y are from 0 to 1 and the sum of x and y is from 0 and 1.

30. The photovoltaic cell of claim 25 wherein the first subcell is fabricated from $Ga_yIn_{1-y}As$ and the second subcell is fabricated from $Ga_xIn_{1-x}As$, wherein x and y are from 0 to 1.

31. The photovoltaic cell of claim 25 wherein the first subcell is fabricated from $Ga_uIn_{1-u}As_vP_{1-v}$ and the second subcell is fabricated from $Ga_xIn_{1-x}As_yP_{1-y}$, wherein x, y, u and v are from 0 to 1 and the sum of any combination of x, y, u and v is from 0 to 1.

32. The photovoltaic cell of claim 12 further comprising:

a third subcell monolithically stacked on the second subcell, the third subcell having a junction of at least one p-type layer of semiconductor material in face-to-face contact with at least one n-type layer of semiconductor material, wherein the third subcell has a lattice constant matched to the lattice constant of the second subcell and wherein the third subcell has a predetermined third band gap energy, the third band gap energy being greater than the second band gap energy; and

a second interconnection layer interposed between the fourth passivation/confinement cladding layer and the third subcell, the interconnection layer comprising materials that facilitate current flow between the second subcell and the third subcell.

33. The photovoltaic cell of claim 32 further comprising:

a fifth passivation/confinement cladding layer interposed between the second interconnection layer and the third subcell, and a sixth passivation/confinement cladding layer positioned on the third subcell, wherein the fifth and sixth passivation/confinement cladding layers comprise materials for minimizing the recombination of carriers within the third subcell and thereby facilitating the third subcell's current and voltage.

34. The photovoltaic cell of claim 32 wherein the photovoltaic cell is a solar photovoltaic cell.

35. The photovoltaic cell of claim 32 wherein the photovoltaic cell is a thermophotovoltaic cell.

36. The photovoltaic cell of claim 34 wherein the first subcell is fabricated from Ge, the second subcell is fabricated from GaAs, and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x has a value from 0 to 1.

37. The photovoltaic cell of claim 34 wherein the first subcell is fabricated from Ge_zSi_{1-z}, the second subcell is fabricated from $GaAs_yP_{1-y}$, and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein the value of x, y, and z are from 0 to 1.

38. The photovoltaic cell of claim 34 wherein the first subcell is fabricated from Ge, the second subcell is fabricated from $Ga_yIn_{1-y}As$, and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein the value of x and y are from 0 to 1.

39. The photovoltaic cell of claim 35 wherein the first subcell is fabricated from $Ga_zIn_{1-z}As$, the second subcell is fabricated from $Ga_yIn_{1-y}As$, and the third subcell is fabricated from $Ga_xIn_{1-x}As$, wherein the values of x, y and z are from 0 to 1.

40. The photovoltaic cell of claim 35 wherein the first subcell is fabricated from $Ga_wIn_{1-w}As_zP_{1-z}$, the second subcell is fabricated from $Ga_uIn_{1-u}As_vP_{1-v}$ and the third subcell is fabricated from $Ga_xIn_{1-x}As_yP_{1-y}$, wherein the values of u, v, w, x, y and z are from 0 to 1 and the sum of any combination of u, v, w, x, y and z is from 0 to 1.

41. The photovoltaic cell of claim 35 wherein the first subcell is fabricated from $Ga_uIn_{1-x}As_ySb_{1-y}$, the second subcell is fabricated from $InAs_yP_{1-y}$ and the third subcell is fabricated from $Al_xIn_{1-x}As$, wherein the values of u, x and y are from 0 to 1 and the sum of any combination of u, x and y is from 0 to 1.

42. The photovoltaic cell of claim 23 further comprising:

a third subcell monolithically stacked on the second subcell, the third subcell having a junction of at least one p-type layer of semiconductor material in face-to-face contact with at least one n-type layer of semiconductor material, wherein the third subcell has a lattice constant matched to the lattice constant of the second subcell and wherein the third subcell has a predetermined third band gap energy, the third band gap energy greater than the second band gap energy; and

a second isolation layer interposed between the sixth passivation/confinement cladding layer and the fourth subcell, the isolation layer comprising materials that prevents current flow between the third subcell and the fourth subcell.

43. The photovoltaic cell of claim 42 further comprising:

a fourth subcell monolithically stacked on the third subcell, the fourth subcell having a junction of at least one p-type layer of semiconductor material in face-to-face contact with at least one n-type layer of semiconductor material, wherein the fourth subcell has a lattice constant matched to the lattice constant of the third subcell and wherein the fourth subcell has a predetermined fourth band gap energy, the fourth band gap energy greater than the third band gap energy; and

a third interconnection layer interposed between the fourth passivation/confinement cladding layer and the third subcell, the interconnection layer comprising materials that facilitate current flow between the second subcell and the third subcell.

44. The photovoltaic cell of claim 43 wherein the photovoltaic cell is a solar photovoltaic cell.

45. The photovoltaic cell of claim 43 wherein the photovoltaic cell is a thermophotovoltaic cell.

46. The photovoltaic cell of claim 44 wherein the first subcell is fabricated from Ge, the second subcell is fabricated from GaAs, and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x has a value from 0 to 1.

47. The photovoltaic cell of claim 44 wherein the first subcell is fabricated from Ge_zSi_{1-z}, the second subcell is fabricated from $GaAs_yP_{1-y}$, and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein the value of x, y, and z are from 0 to 1.

48. The photovoltaic cell of claim 44 wherein the first subcell is fabricated from Ge, the second subcell is fabricated from $Ga_yIn_{1-y}As$, and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein the value of x and y are from 0 to 1.

49. The photovoltaic cell of claim 45 wherein the first subcell is fabricated from $Ga_zIn_{1-z}As$, the second subcell is fabricated from $Ga_yIn_{1-y}As$, and the third subcell is fabricated from $Ga_xIn_{1-x}As$, wherein the values of x, y and z are from 0 to 1.

50. A photovoltaic cell for converting radiant energy into electrical energy, the photovoltaic cell comprising:

a first subcell having a base layer of silicon, an intermediate layer of silicon oxide, a top layer of perovskite oxide, the base layer of silicon having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein and having a first band-gap energy, the intermediate layer of silicon oxide electrically isolating the base layer of silicon;

a second subcell monolithically stacked on the compliant substrate composed of a semiconductor material having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein and having a second band-gap energy, the second band-gap energy greater than the first band-gap energy; and

terminals attached to the photovoltaic cell to conduct current from and into the photovoltaic cell.

51. The photovoltaic cell of claim 50 wherein the photovoltaic cell is a solar photovoltaic cell.

52. The photovoltaic cell of claim 50 wherein the photovoltaic cell is a thermophotovoltaic cell.

53. The photovoltaic cell of claim 51 wherein the subcell is fabricated from a semiconductor material selected from a group consisting of GaAs, InP, $Ga_xIn_{1-x}P$,

$GaAs_xP_{1-x}$, $Al_xIn_{1-x}As$, $Al_xIn_{1-x}As$, $Al_xGa_{1-x}As$, $Al_xGa_yIn_{1-x-y}$, $Ga_xIn_{1-x}As_yP_{1-y}$, $Al_xGa_{1-x}As_ySb_{1-y}$, $Al_xGa_yIn_{1-x-y}As$, wherein the values of x and y are from 0 to 1 and the sum of any combination of x and y is from 0 to 1.

54. The photovoltaic cell of claim 51 wherein the second subcell is fabricated from a semiconductor material selected from a group consisting of GaAs and InP.

55. A photovoltaic device for converting radiant energy into electrical energy, the photovoltaic device comprising:

an array of photovoltaic cells, each photovoltaic cell comprising:

a first subcell having a base layer of silicon, an intermediate layer of silicon oxide, a top layer of perovskite oxide, the base layer of silicon having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein and having a first band-gap energy, the intermediate layer of silicon oxide electrically isolating the base layer of silicon;

a second subcell monolithically stacked on the compliant substrate composed of a semiconductor material having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein and having a second band-gap energy, the second band-gap energy greater than the first band-gap energy; and

a first subcell string formed by serially interconnecting at least one first subcell from the array of photovoltaic cells to another first subcell from the array of photovoltaic cells; and

a second subcell string formed by serially interconnecting at least one second subcell from the array of photovoltaic cells to another second subcell from the array of photovoltaic cells

wherein the number of subcells in the first subcell string is adjusted to provide a first voltage and the number of subcells in the second subcell string is adjusted to provide a second voltage, the first and second voltages being substantially matched.

56. The photovoltaic device of claim 55 wherein the photovoltaic device is a solar photovoltaic device.

57. The photovoltaic device of claim 55 wherein the photovoltaic device is a thermophotovoltaic device.

58. The photovoltaic device of claim 56 wherein the second subcell is fabricated from a semiconductor material selected from a group consisting of GaAs, InP, $Ga_xIn_{1-x}P$, $GaAs_xP_{1-x}$, $Al_xIn_{1-x}As$, $Al_xIn_{1-x}As$, $Al_xGa_{1-x}As$, $Al_xGa_yIn_{1-x-y}$, $Ga_xIn_{1-x}As_yP_{1-y}$, $Al_xGa_{1-x}As_ySb_{1-y}$, $Al_xGa_yIn_{1-x-y}As$, wherein the values of x and y are from 0 to 1 and the sum of any combination of x and y is from 0 to 1.

59. The photovoltaic device of claim 56 wherein the second subcell is fabricated from a semiconductor material selected from a group consisting of GaAs and InP.

60. The photovoltaic device of claim 55 wherein the photovoltaic cell further comprises a third subcell monolithically stacked on the second subcell, the third subcell composed of a semiconductor material having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein, and having a third band-gap energy, the third band-gap energy greater than the second band-gap energy, and wherein the photovoltaic device further comprises a third subcell string formed by serially interconnecting at least one third subcell from the array of photovoltaic cells to another third subcell from the array of photovoltaic cells, wherein the number of subcells in the third subcell string is adjusted to provide a third voltage, the third voltage being substantially matched to the first and second voltages.

61. The photovoltaic device of claim 60 wherein the photovoltaic device is a solar photovoltaic device.

62. The photovoltaic device of claim 60 wherein the photovoltaic device is a thermophotovoltaic device.

63. The photovoltaic device of claim 61 wherein the second subcell is fabricated from GaAs and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x has a value of from 0 to 1.

64. The photovoltaic device of claim 61 wherein the second subcell is fabricated from $GaAs_vP_{1-v}$ and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x and v have a value of from 0 to 1.

65. The photovoltaic device of claim 61 wherein the second subcell is fabricated from $GaAs_yP_zN_{1-y-z}$ and the third subcell is fabricated from $Ga_xIn_{1-x}P$, wherein x, y, and z have values of from 0 to 1 and the sum of any combination of y and z is from 0 to 1.

66. The photovoltaic device of claim 61 wherein the second subcell is fabricated from $Ga_xIn_{1-x}P$ and the third subcell is fabricated from $Al_xIn_{1-x}P$, wherein x has a value of from 0 to 1.

67. The photovoltaic device of claim 61 wherein the second subcell is fabricated from GaAs and the third subcell is fabricated from $Al_xGa_{1-x}As$, wherein the value of x is from 0 to 1.

68. A photovoltaic device for converting radiant energy into electrical energy, the photovoltaic device comprising:

an array of photovoltaic cells, each photovoltaic cell comprising:

a compliant substrate having a base layer of silicon, an intermediate layer of silicon oxide, a top layer of perovskite oxide, the compliant substrate accommodating monolithic growth of semiconductor materials having a lattice constant from about 5.4 Å to about 5.9Å;

a first subcell monolithically stacked on the compliant substrate, the first subcell composed of a semiconductor material having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein and having a first band-gap energy; and

a second subcell monolithically stacked on the first subcell, the second subcell composed of a semiconductor material having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein and having a second band-gap energy, the second band-gap energy greater than the first band-gap energy;

a first subcell string formed by serially interconnecting at least one first subcell from the array of photovoltaic cells to another first subcell from the array of photovoltaic cells; and

a second subcell string formed by serially interconnecting at least one second subcell from the array of photovoltaic cells to another second subcell from the array of photovoltaic cells

wherein the number of subcells in the first subcell string is adjusted to provide a first voltage and the number of subcells in the second subcell string is adjusted to provide a second voltage, the first and second voltages being substantially matched.

69. The photovoltaic device of claim 68 wherein the photovoltaic device is a solar photovoltaic device.

70. The photovoltaic device of claim 68 wherein the photovoltaic device is a thermophotovoltaic device.

71. The photovoltaic device of claim 69 wherein the first subcell is fabricated from GaAs and the second subcell is fabricated from $Ga_xIn_{1-x}P$, wherein the value of x is from 0 to 1.

72. The photovoltaic device of claim 69 wherein the first subcell is fabricated from $Ga_xIn_{1-x}As$ and the second subcell is fabricated from $Ga_xIn_{1-x}P$, wherein the value of x is from 0 to 1.

73. The photovoltaic device of claim 69 wherein the first subcell is fabricated from $Ga_xIn_{1-x}As$ and the second subcell is fabricated from InP, wherein the value of x is from 0 to 1.

74. The photovoltaic device of claim 70 wherein the first subcell is fabricated from $Ga_yIn_{1-y}As$ and the second subcell is fabricated from $Ga_xIn_{1-x}As$, wherein the values of x and y are from 0 to 1.

75. The photovoltaic device of claim 70 wherein the first subcell is fabricated from $Ga_yIn_{1-y}As$ and the second subcell is fabricated from $InAs_xP_{1-x}$, wherein the values of x and y are from 0 to 1.

76. A light emitting device for converting electrical energy into light, the light emitting device comprising:

an array of light emitting cells, each light emitting cell comprising:

a compliant substrate having a base layer of silicon, an intermediate layer of silicon dioxide, a top layer of perevskite oxide, the compliant substrate accommodating monolithic growth of semiconductor materials having a lattice constant from about 5.4 Å to about 5.9Å;

a first subcell monolithically stacked on the compliant substrate, the first subcell composed of a semiconductor material having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein, the semiconductor material having a lattice constant accommodated by the compliant

substrate, the semiconductor material having a first band-gap energy characteristic of the emission of red light in response to sufficient voltage;

a second subcell monolithically stacked on the first subcell, the second subcell composed of a semiconductor material having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein, the semiconductor material lattice matched to the first subcell, the semiconductor material having a second band-gap energy characteristic of the emission of green light in response to sufficient voltage; and

a third subcell mechanically stacked on the second subcell, the third subcell composed of a semiconductor material having a junction of at least one p-type region in face-to-face contact with at least one n-type region therein, the semiconductor material having a third band-gap energy characteristic of the emission of blue light in response to sufficient voltage;

a first subcell string formed by serially interconnecting at least one first subcell from the array of light emitting cells to another first subcell from the array of light emitting cells;

a second subcell string formed by serially interconnecting at least one second subcell from the array of light emitting cells to another second subcell from the array of light emitting cells; and

a third subcell string formed by serially interconnecting at least one third subcell from the array of light emitting cells to another third subcell from the array of light emitting cells;

wherein the first subcell string, second subcell string and third subcell string are independently tuned to produce a target hue of light.

77. The photovoltaic device of claim 76 wherein the first subcell is fabricated from $Al_xGa_yIn_{1-x-y}As_z$, the second subcell is fabricated from $Al_xGa_yIn_{1-x-y}As_zP_{1-z}$, and the third subcell is fabricated from $Ga_xIn_{1-x}N$, wherein the values of x, y and z are from 0 to 1 and the sum of any combination of x, y and z is from 0 to 1.